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REGENERATION AND EARLY GROWTH ON STRIP CLEARCUTS IN LODGEPOLE PINE/BITTERBRUSH HABITAT TYPE

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ABSTRACT

Establishment and growth of seedlings 13 years after strip clearcutting was investigated on a lodgepole pine/bitterbrush habitat type in southwestern Montana. Ingress of new seedlings (all from open-coned lodgepole pine) on areas that had been heavily bulldozer scarified was considerably better than on areas without bulldozer scarification. Seed:seedling ratios (established seedlings) ranged from 625:1 to 2,160:1 on scarified sites, and from 1,876:1 to 6,480:1 on unscarified sites. Only 3 years out of 13 resulted in significant numbers of seedlings being established. Advanced regeneration released by logging was growing as rapidly as seedlings established following logging.

KEYWORDS: lodgepole pine regeneration, lodgepole pine growth, site preparation

Proper site preparation is an important tool in regenerating lodgepole pine stands following logging. Slash disposal methods and site preparation techniques also may affect various parameters of site quality, and thus influence not only the regeneration stage but also growth of the new stand. Studies have shown that lodgepole pine becomes established most easily on disturbed seedbeds (Alexander 1966; Lotan 1964), and that method of slash disposal may influence height growth during the first 2 years following

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planting or direct seeding (Lotan and Perry 1977). However, we have little knowledge concerning long-term effects of different site preparation and slash disposal techniques.

This paper contrasts the effects of extreme soil disturbance (bulldozer scarification) and light soil disturbance on ingress of regeneration and growth of seedlings 13 years after logging.

SITE CHARACTERISTICS

The study area, near West Yellowstone, Montana, is a level plain with virtually no microsite differences. Soils are loamy sands with low water holding capacity formed from alluvial deposits of obsidian and rhyolite (Stermitz and others 1974). Forests are pure, uneven-aged (0 to 230 years) lodgepole pine, with 38 percent of the trees having serotinous cones (Lotan 1967). Habitat type is *Pinus contorta/Purshia tridentata* (Pfister and others 1977). This type occurs near West Yellowstone and has not been defined elsewhere (although it may be similar to lodgepole pine sites which occur on pumice in central Oregon). Average site index (100-year base) is 40. Clearcuts have a sparse cover, primarily composed of various sedges and grasses. Scattered shrubs of bitterbrush (*Purshia tridentata*) also occur. Elevation of the sites is 2,188 ± 8 m.[2] The area has a continental mountain climate, with cold winters and a short growing season. From 1962 through 1975, an average of 14 days during June, July, and August had below freezing temperatures. Growing season (June-August) precipitation during the same period averaged 147 mm, 51 percent of which occurred in June, 22 percent in July, and 27 percent in August (U.S. Weather Bureau 1962-1975).

PROCEDURE

Strips were logged in May 1963. Two of them (numbers 1 and 3) were approximately 80 by 500 m, and one (number 2) was 120 by 500 m in size. All strips were oriented perpendicular to prevailing winds (southwesterly). On roughly 25 percent of each strip, slash was burned in place, and on the remainder, it was windrowed (using a bulldozer) and burned. In the windrowing process, the top few centimeters of soil and all competing vegetation were removed. All burnings were done in September 1963. Closed cones in the slash had not opened; thus input of seed from this source was negligible.

Trees had been felled so that they lay in somewhat of a herringbone pattern; that is, slash was concentrated in strips rather than distributed randomly. Therefore, the "burned in place" treatment was not exactly a broadcast burn (roughly 20 percent of the area was burned). Principal differences between the two treatments were (1) the degree of soil disturbance associated with slash cleanup, and (2) the presence of advanced regeneration (residual trees) on the "burned in place" and not on the "dozer-piled" treatment (any present were uprooted in the piling process).

Density, stocking, and growth were measured in late summer and early fall of 1976. Sampling lines (10 in windrowed areas and 4 in broadcast burns) were laid out randomly, perpendicular to the long axis of the strip. On each of these, a plot was established approximately every 8 m (distances were paced). Each plot was circular, 16 m^2 in area, and was divided into four quadrants of 4 m^2 each. The number of trees in each quadrant was counted. Density was determined from the total count, and stocking from the percentage of quadrants having trees. A circular 4 m^2 plot was laid out within and having the same center point as the 16 m^2 plot, and all trees within it were felled. Age at ground level was determined from ring count with a hand lens, and total height was measured to the nearest centimeter.

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[2] 1 m = 3.28 feet; 10,000 square meters (m^2) = 1 hectare (ha) = 2.47 acres; 4 m^2 = 1 milacre; 1 cm = 0.4 inch; 1 mm = 0.04 inch; 1 km = 0.62 mile.

Twenty-four advanced trees (established before logging) were selected to represent a range of sizes and were felled to determine their response to release. None of these were located within areas where slash concentrations had been burned, and so should not have been affected by fire. Age, diameter, and radial growth in the past 10 years were determined at ground level--0.5 m, 1 m, and every subsequent 1 m for the total height of the tree. The same measurements were made on 10 trees of similar height growing under the adjacent forest canopy.

Seedfall in 1963, 1965, and 1968 was determined from 1-m^2 seed traps placed at 22-m intervals across each strip (eight traps per strip). Rainfall data are taken from a U.S. Weather Bureau weather station at West Yellowstone, about 8 km from the study sites. Comparison with a standard rain gage operated on one of the strips from 1962 through 1967 shows that West Yellowstone rainfall was representative of that on the study sites (r^2 equal to or greater than 0.89 in all months except August, when it was 0.67).

Stocking and density differences between the two site preparation techniques within each strip were compared using a "t" test. Because of site uniformity, no position effect is expected in this analysis. Growth differences between released residual trees and trees under the forest canopy were also compared by "t" test. Multivariate-regression analysis (Grosenbaugh 1967) was used to test the relation between seedling establishment and weather variables.

RESULTS AND DISCUSSION

Stocking and Density

Dozer-piled (DP) areas averaged 1,333 trees per ha with 24 percent stocking. (To find trees per acre, multiply per ha value by 0.39). Burned-in-place (BP) areas averaged 645 trees per ha, approximately 30 percent of which was advanced regeneration, with 15 percent stocking. However, there was considerable difference in the response of individual strips (fig. 1). In strip 1, density and stocking are better on DP than on BP areas, and apparently also in strip 2 (table 1). In strip 3, although there are nearly one-third more new seedlings on DP than on BP areas, no statistical difference can be shown. Differences among the strips reflected changes in seedling density in both BP and DP areas. The high density in the BP treatment in strip 3 was partially due to a large amount of advanced regeneration. Seed production was generally highest surrounding strip 1 and lowest surrounding strip 2; however, this apparently had little influence on relative stocking among the strips.

Table 1.--*Probability that treatment effects are different*

Treatment	Strip 1	Strip 2	Strip 3
Density			
including advanced regeneration	>0.999	0.92	0.62
not including advanced regeneration[1]	>.999	.93	.41
Stocking (including advanced regeneration)	>.999	.92	.67

[1] Mean density without advanced regeneration was estimated by subtracting the proportion of trees established before logging, determined by ring counts on felled seedlings, from the density obtained by the count within 16-m^2 plots. (Proportion determined for each strip separately.)

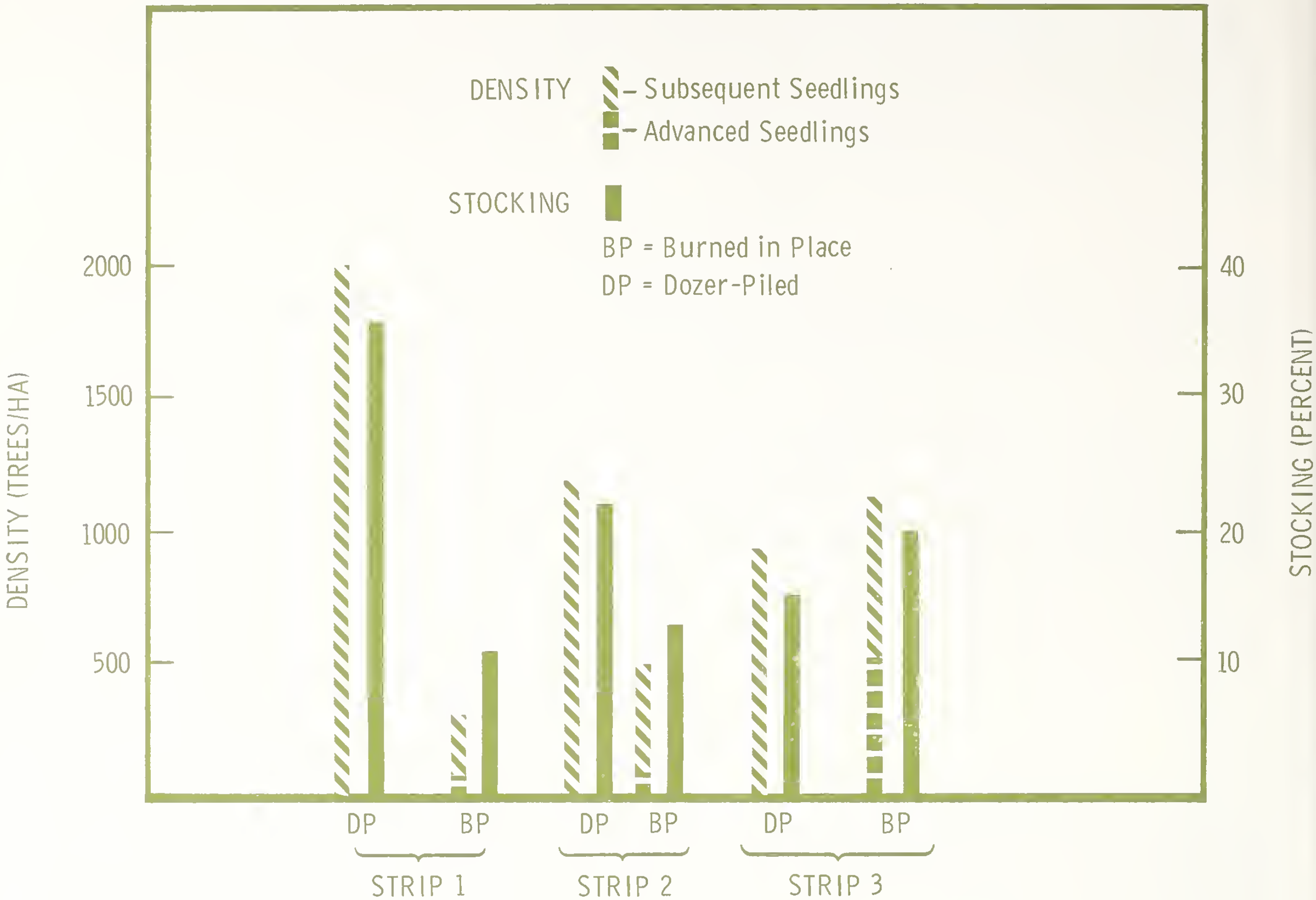

Figure 1.--Density and percent stocking of regeneration on three strip clearcuts, by site preparation technique.

Seed:seedling ratios (seedlings surviving to 1976) for the 3 years of recorded seedfall (1963, 1965, 1968) ranged from 625:1 to 2,160:1 on DP areas, and from 1,876:1 to 6,480:1 on BP sites. Ratios within 8 m of the south timber edge were approximately 10 times higher than beyond, despite the ameliorating effect of shade, which may have benefited competing vegetation more than it did tree seedlings. Nevertheless, in DP areas, 37 percent of seedlings were in this area, reflecting the large amounts of seed falling near the timber edge (fig. 2). Beyond 8 m, seedling density was fairly evenly distributed across the strips. Similar clumping of seedlings near the south timber edge did not occur on BP areas, possibly because of the extremely low number of microsites suitable for seedling establishment on the undisturbed seedbeds.

Only 3 years out of 14 resulted in significant seedling establishment. These followed one another, resulting in a normal curve of seedling ingress (fig. 3). Crossley (1976) has reported the same pattern on a number of lodgepole pine clearcuts in Alberta: seedling establishment is low in the first few years following harvest, increases rapidly, peaks about the 6th year, then declines rapidly. Although we cannot explain this pattern, it may be related to reoccupation of the site by other vegetation, which provides increasing cover (site amelioration) up to a point, after which competitive effects begin to dominate. Weather variables alone explained very little of the year-to-year variation in seedling establishment.

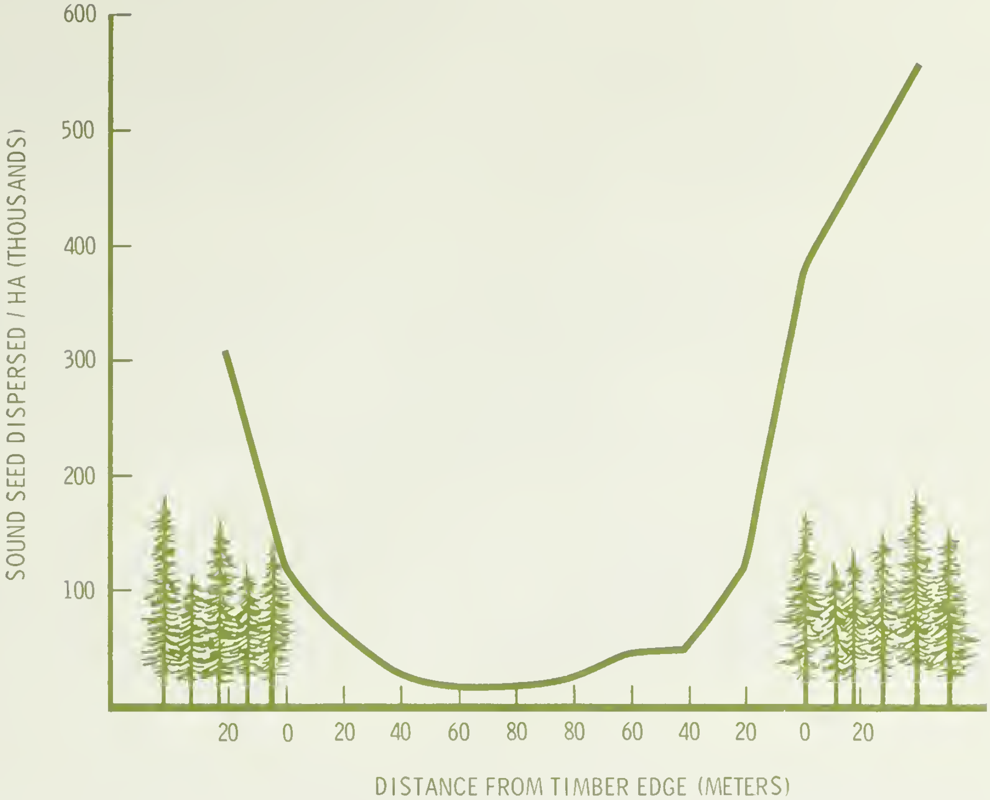

Figure [illegible].—Lodgepole pine seed dispersal into strip clearcuts. [illegible] years data on three sites near West Yellowstone, Montana. Adjacent stands are [illegible] lodgepole pine. Thirty-eight percent of trees have predominantly serotinous cones.

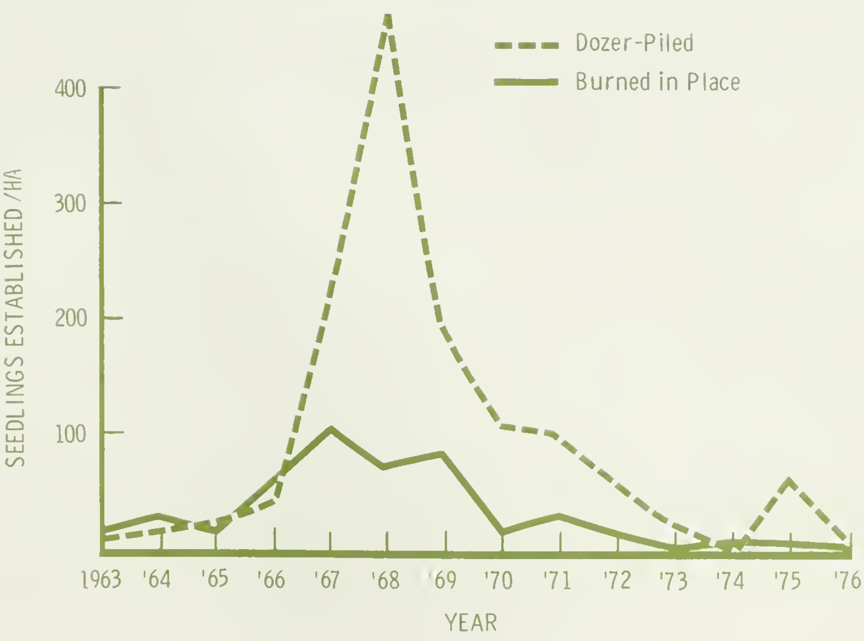

Figure 7.--Seedling establishment by year, [illegible]

Seedling Growth

Seedlings on BP areas averaged 17 percent taller than those in DP treatments (108 cm vs. 85 cm; significant at the 0.01 level); due solely to the advanced regeneration on the BP sites. Average growth rate of seedlings established since logging was not different on the two treatments (0.10 m/yr for both). Variation among seedlings in growth rate was also similar--the standard deviation 4.4 cm/yr on BP areas, and 4.0 cm/yr on DP areas.

Released trees are growing at a rate equal to or greater than that of seedlings established since logging, which may be partly due to the fact that trees accelerate growth after a certain size regardless of treatment. Even under the forest canopy, trees sharply increased their height growth rate after reaching 1 m (significant at the 0.001 level); however, they still did not match the growth rate of trees released by logging. In 1976, leader growth averaged 23 cm on released trees and 15 cm on trees under the forest canopy (difference significant at the 0.01 level). Age at the time of release (up to 55 years, maximum measured) did not seem to be a factor in ability to respond.

Average diameter growth per year over the past 10 years was 3.8 mm for released trees and 1.6 mm for trees growing under the forest canopy (difference significant at the 0.001 level). Among released trees, radial increment at 1 m averaged 27 percent greater and at 2 m, 70 percent greater than that at 0.5 m and ground level. Therefore, "butt swell," which has been noted in released trees of other species did not occur in this case.

At the densities experienced here, crowding had very little effect on seedling growth. Tree density in a 4-m^2 plot centered on the sample tree (range: 1 to 16 trees per plot) did not affect 1976 leader growth (r^2 = 0.003), and had a slight negative effect on average yearly increment (r^2 = 0.23).

Suppressed lodgepole pine has also been shown to respond to release in British Columbia (Keith Illingworth. 1961. Lodgepole pine in the southeastern interior of British Columbia: a problem analysis. B.C. For. Serv.) and in the Blue Mountains of Oregon (Trappe 1959). This may be generally true, providing trees have a vigorous crown and have not been suppressed for longer than 50 or 60 years. However, we don't know how many years an older tree that is released can maintain its accelerated growth. Until we have this answer, it should be assumed that trees suppressed for longer than 10 or 15 years will not sustain rapid growth for a significant period after release.

CONCLUSIONS

Several previous studies have shown that lodgepole pine regenerates better on a disturbed seedbed than on an undisturbed seedbed (see citations in the introduction) Our study generally supports this theory but on our sites the degree of establishment on disturbed and undisturbed areas varied considerably. We are unable to explain the differences in our three strips; however, we are still seeking the answer.

Our results strongly indicate that, on these sites, seedlings present in the stand at the time of logging will respond to release and may form a very important component of the regeneration. The presence of advanced regeneration should be considered when evaluating the degree of site disturbance needed. If advanced regeneration is left, it is critically important that all sources of dwarf mistletoe infection be removed. Where the understory is heavily infected, it is probably better to remove all residual trees.

This habitat type is exceptionally droughty and nutrient poor. The level of vegetative competition is low compared to more productive sites. Therefore, use caution when extrapolating these results to other environmental conditions.

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